

Physics Opportunities with an Intense Proton Source

P. Meyers, for the FLRPC Proton Driver SubCom

- The current Fermilab program
- Long-baseline neutrino prospects
- Counting protons (dumb version)
- Other programs/benefits

Draft 2005-8 Fermilab Accelerator Experiments Schedule

Revised Annually - This Version from June, 2003

Year		2005	2006	2007	2008
Tevatron Collider				BTeV	BTeV
		CDF & Dzero		CDF & Dzero	CDF & D0
Neutrino Program	B	OPEN	OPEN	OPEN	OPEN
	MI	MINOS	MINOS	MINOS	MINOS
Meson 120	MT	Test Beam		Test Beam	TestBeam
	MC	OPEN	OPEN	OPEN	E906
	ME/P	OPEN	OPEN	OPEN	OKM

Draft 2009-12 Fermilab Accelerator Experiments Schedule

Revised Annually - This Version from June, 2003

Year		2009	2010	2011	2012
Tevatron Collider		BTeV	BTeV	BTeV	OPEN
			OPEN	OPEN	OPEN
Neutrino Program	B		OPEN	OPEN	OPEN
	MI		OPEN	OPEN	OPEN
Meson 120	MT	Test Beam	Test Beam	Test Beam	TestBeam
	MC	E906-DrellYan	E906-DrellYan	OPEN	OPEN
	ME/P	CKM	CKM	CKM	OPEN

- RUN or DATA
- STARTUP/COMMISSIONING
- INSTALLATION
- M&D (SHUTDOWN)

Some facts:

- Lots of exciting physics coming!
- ~2008: highest energy goes to LHC
- ~2005: Fermilab becomes **the place where neutrino oscillation results come from**

Compelling case for exploiting and extending
the Fermilab neutrino program

- Exciting physics to explore
- Utilize elements in place
- Utilize local expertise

References:

- Stephen Parke's presentation at
“Physics Landscapes” Open Session 9/16
- Upcoming “Neutrino” Open Session 11/7

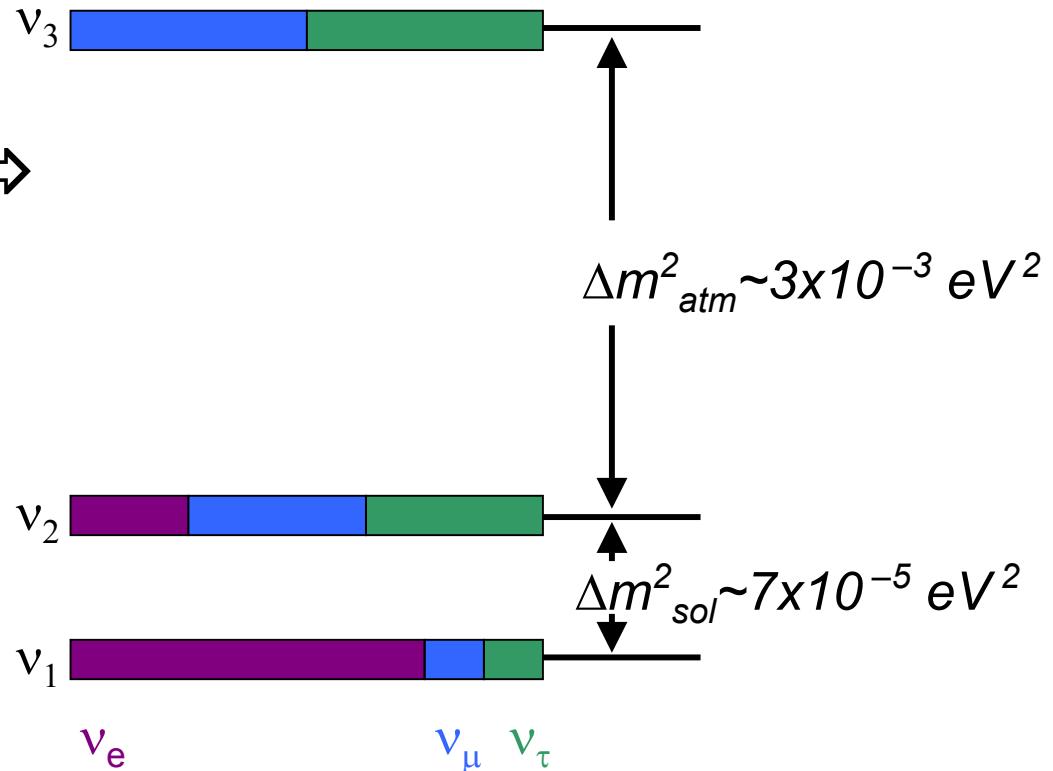
Slide under construction!

VERY brief overview of neutrino situation

Solar + atmospheric \Rightarrow
a consistent picture

$\square \theta_{12} \sim \pi/6, \theta_{23} \sim \pi/4, \theta_{13} < 0.2$

$\square \delta = ???$

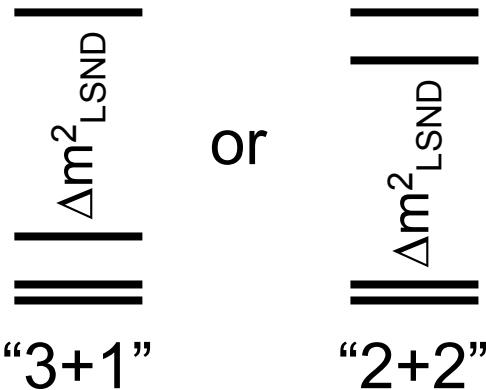


$$U = \begin{matrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{matrix} \begin{bmatrix} c_{12}c_{13} & s_{12}c_{13} & s_{13}e^{-i\delta} \\ -s_{12}c_{23} - c_{12}s_{23}s_{13}e^{i\delta} & c_{12}c_{23} - s_{12}s_{23}s_{13}e^{i\delta} & s_{23}c_{13} \\ s_{12}s_{23} - c_{12}c_{23}s_{13}e^{i\delta} & -c_{12}s_{23} - s_{12}c_{23}s_{13}e^{i\delta} & c_{23}c_{13} \end{bmatrix}$$

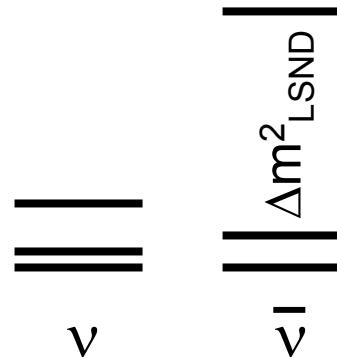
with $c_{ij} \equiv \cos \theta_{ij}$ $s_{ij} \equiv \sin \theta_{ij}$

Slide under construction!

3 active + 1 sterile



CPT violation



- hard to make work
- limits on ν_s in solar and atmospheric: ~~2+2~~
- short-baseline exclusion on disappearance: ~~~3+1~~
- on to "3+2"?

- level of ~~CPT~~ required is $< K^0 - \bar{K}^0$ mass limit
- on the other hand, it *is* a theorem...
- incompatible with atmospheric?

From the current round --

- MiniBooNE, Minos, K2K
- more from Super-K, SNO, Kamland...

we will have:

LSND: yes or no

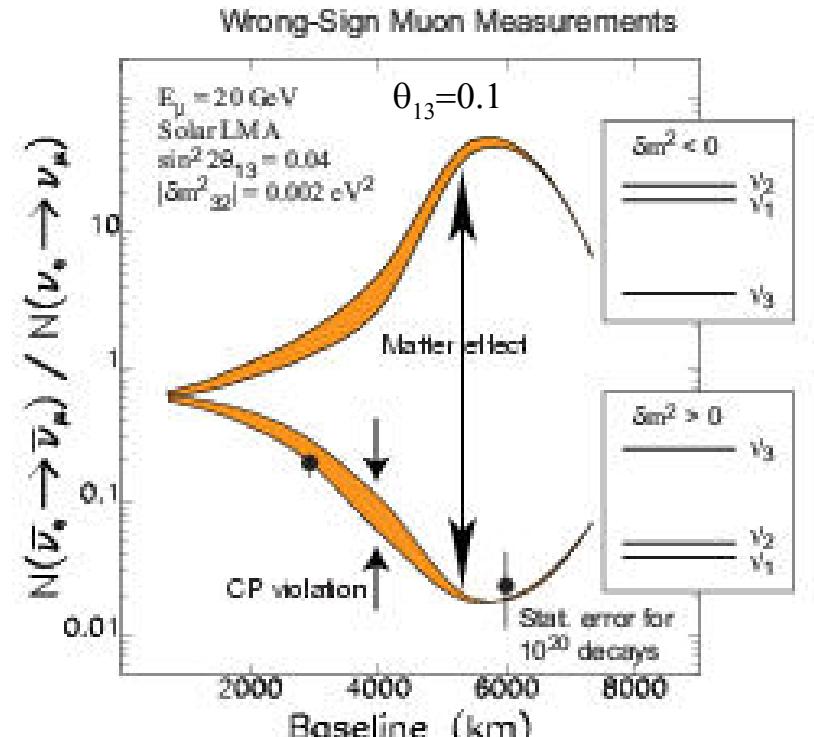
- New physics!
- Short baseline stays interesting
- Plus all this (with different meaning)

- Δm^2_{atm} , Δm^2_{sol} well measured
- θ_{12} , θ_{23} pretty well known
- Know if $\theta_{13} \gtrsim 0.1$ or not

Slide under construction!

The next goals:

- Further confirming the picture (cf. CKM)
- Ordering the mass hierarchy
- CP violation
- θ_{13} is the gatekeeper

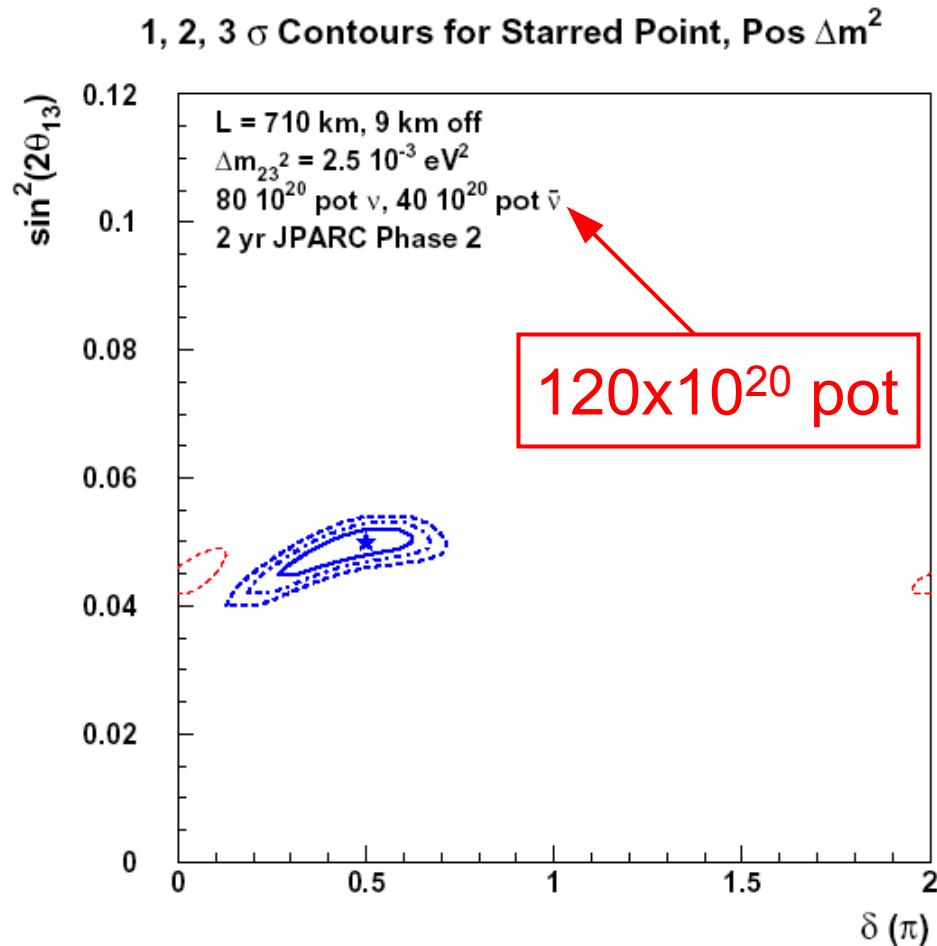


Barger et al., hep-ph/0003184

$$P(\nu_e \rightarrow \nu_\mu) - P(\bar{\nu}_e \rightarrow \bar{\nu}_\mu) = 16 s_{12} c_{12} \underline{s_{13}} c_{13}^2 s_{23} c_{23} \times$$

$$\underline{\sin \delta} \sin \left(\frac{\Delta m_{12}^2 L}{4E} \right) \sin \left(\frac{\Delta m_{13}^2 L}{4E} \right) \sin \left(\frac{\Delta m_{23}^2 L}{4E} \right)$$

NuMI 4 yr ν , 2 yr $\bar{\nu}$, Proton Driver and JPARC, Phase 2



Hierarchy finally resolvable at > 95% CL with 6 yrs of proton driver.

(real story in next talk...)

Era	Program	Need (10^{20} p.o.t./yr)		Available ($10^{20}/\text{yr}$)	
		Booster	MI	Booster	MI
Current	Run II	0.5	0.5		
	MBooNE	5 — 5.5	0.5	2.7 → 5.5	0.5
Near-term ~2005	Run II	0.5	0.5		
	Minos	2	2		
	MBooNE?	5 — 7.5	2.5	5.5 → 7.6	3.2
Mid-term ~2008	Run II	0.5	0.5		
	Minos	4	4		
	BooNE?	5 — 9.5	4.5		
Long-term ~2010	Off-axis (BTeV,CKM)	20	20		

$$\frac{20 \times 10^{20} \text{ pot/yr} \times 120 \times 10^9 \text{ eV} \times 1.6 \times 10^{-19} \text{ J/eV}}{2 \times 10^7 \text{ s/yr}} =$$

1.9 MW

Proton Driver: 0.5-2 MW at 8 GeV

Current Booster: ~0.02 MW (\rightarrow 0.04? \rightarrow 0.05?)

Fermilab: in...or out?

J-PARC → Kamioka (2007?)

- 295 km baseline -- matter effects small
- 0.75 MW → 4 MW

Brookhaven → Homestake/WIPP (????)

- 2500-2900 km baseline
- 1 MW

Other Proton Driver Physics

- Two Fermilab studies
- Short-baseline neutrino oscillation
 - if MiniBooNE confirms LSND
 - multiple sterile neutrinos?
- Low-energy neutron source
 - optimize for elementary particle physics
- Low-energy muon source

Head-start for bigger projects?

- SC Linac a warm-up (cool-down?) for LC
- ν Factory R&D/source

Big questions:

- PD and various LC scenarios
- What does 2012 look like
without PD?